THE APONEUROSES THE SUPPORTING STRUCTURES OF THE ABDOMINAL WALL; THEIR APPROXIMATION FOR THE PREVENTION AND CURE OF HERNIA.

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Of the various structures entering into the composition of the belly wall,—skin, fat, superficial fascia, aponeurotic laminæ, muscle, transversalis fascia, and peritoneum,—the aponeuroses are the chief factors in the prevention of hernia. Neither the skin nor peritoneum offer much resistance to visceral protrusions, and that offered by muscles alone is not great when unprotected by fibrous covering. Witness hernia of muscle itself when, for instance, the sheath of the rectus is wounded. The protection of viscera and the production of movements constitute the principal rôle of the four flat abdominal muscles. The bellies of the transverse and oblique muscles fill in the space between the lower borders of the costal cartilages and the crest of the ilium on the sides of the abdomen, where hernia is least apt to occur, while behind this point the aponeurosis of the transversalis divides into three layers separating and giving support to the lumbar muscles. Anteriorly, the aponeurosis of the oblique and transverse muscles cover and support the whole front of the belly for an area extending from without the borders of the recti on the sides, and from the ensiform cartilage to the pubes in front. The aponeurotic layer of the external oblique is of the greatest importance, stretching, as it does, from beneath the pectoral muscles over the recti to the symphysis, and from the crest and anterior superior spine of the ilium to the spine of the pubis, forming Poupart's ligament and the pillars of the abdominal ring. It is mainly owing to weakness or faulty approximation of this structure that hernia results. The aponeurosis of the internal oblique, beginning well outside the rectus, divides into two layers at the outer border of the upper three-quarters of this muscle, one layer passing in front and the other layer behind the rectus to form its sheath, and uniting in the middle line.

While in the lower quarter of the rectus the aponeurosis of the internal oblique does not divide, but passes over the front of the muscle. The aponeurosis of the transversalis is broad, its upper three-fourths passing behind the rectus, blending with the aponeurosis of the internal oblique in front and the transversalis fascia behind, while its lower fourth passes in front of the rectus and, with the upper three-fourths, is inserted in the middle line (Fig. 1). All the aponeurotic layers pass in front of the lower fourth of the rectus; none behind this part.

The linea alba, formed by the blending of the transverse and oblique muscles, is wider above, and is of considerable breadth here when the abdomen has been distended, as by pregnancy. In operations for umbilical hernia or separation of the recti, the linea alba will often be found to afford sufficient tissue for making flaps without encroaching on the sheath of the rectus. As there is an aperture in the aponeuroses at the umbilicus, hernia in this region is only covered by peritoneum, transversalis fascia, and skin in most instances; but when, owing to separation of the recti, a large area of aponeurosis exists in the middle line, it will not uncommonly be found that this enters into the covering of umbilical hernia, particularly in large herniæ which have encroached upon the abdominal wall. In these it is especially necessary to find sufficient material for flaps in performing overlapping of the aponeurosis; therefore part of the base of the sac, composed of peritoneum and aponeurosis, may be utilized for this purpose. In a recent case of operation for ventral hernia with diastasis of the recti, it was noticed that the hernial covering consisted only of skin and peritoneum in the most central and superficial part, while about the periphery the aponeurosis entered into its composition. This was an incisional hernia following an operation

FIG I

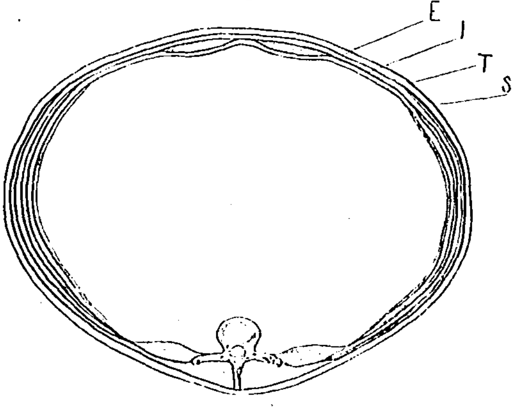

FIG. 2

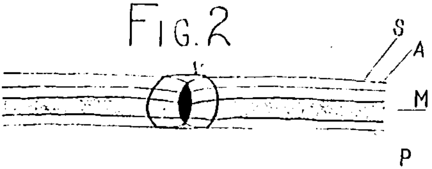

FIG. 3

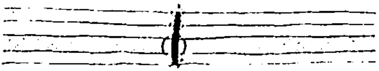

FIG 4

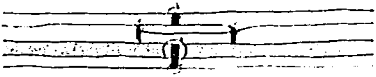

FIG. 1.—Cross-section of abdominal parietes showing the arrangement of aponeuroses in the upper three-fourths of the belly. E. Aponeurosis of external oblique. I. Aponeurosis of internal oblique. T. Aponeurosis of transversalis. S. Skin.

FIG. 2.—S. Skin. A. Aponeurosis. M. Muscle. P. Peritoneum. Mass or through-and-through suture of abdominal wall showing thinning of wall through tension of stitches and direct line of broad scar tissue from peritoneum to skin. More or less puckering of the layers and lack of or faulty approximation of the aponeurosis—which are not uncommon—are not shown.

FIG. 3.—Suture of the abdominal wall by layers. There is good approximation of like structures, but a weak spot in the direct line of the cicatrix from peritoneum to surface, which often results in hernia.

FIG. 4.—Closure of the abdominal incision by overlapping the aponeurosis. There is no direct line of scar formation from peritoneum to skin, but instead there is a doubling of the strongest layer in the wall interposed right in the path of hernia. The broad line of union between the flaps of aponeurosis making a breaking down of the wound an impossibility.

done in the middle line some years before by an unknown operator, and the result showed the effect of not properly approximating the aponeurosis in closing the incision.

Let us now consider the more common methods of making and closing the abdominal incision so far as they relate to the prevention and cure of hernia. We will analyze them from two points of view. 1. Their anatomical correctness. 2. Their clinical results. In the case of the earliest method, that of the so-called through-and-through or mass suture penetrating all layers of the wall from peritoneum to skin, several faults are apparent. Like structures are not accurately approximated; the peritoneum may be separated by bulging muscle; the aponeurosis is not properly coapted; the layers are puckered and suffer considerable tension at points where the stitches are placed resulting in thinning of the walls. Faulty approximation leads to a wide scar formation, and this, being weak tissue and extending in an unbroken line from peritoneum to skin, readily yields and gives rise to abdominal hernia which has been justly styled the "one blot upon abdominal surgery" (Fig. 2). Indeed, so late as 1895, Winter in *La Semaine Médicale,* relates that postoperative hernia had resulted in about one-third of 1000 cases of laparotomy done in the various hospitals of Berlin by the older method of mass suture.

Next came suturing of the separate layers or tiers. While it is true that by this procedure close approximation of like tissues, freedom from tension, and a linear scar are secured, yet the cicatricial tissue being continuous in the line of incision through the whole substance of the wall, hernia is a frequent occurrence. For example, such excellent operators as Bull and Coley report twelve relapses out of twenty-one cases of ventral and umbilical hernia done, as Coley writes me, by suture of separate layers. These cases are, as a rule, extremely unfavorable in possessing exceptionally weak walls; but when we compare this result with that of almost complete success in similar cases obtained by overlapping the aponeurosis, we find that the comparison does not reflect credit on suture of separate layers alone as a means of preventing or curing hernia in weak abdominal walls (Fig. 3). "Comparisons are odious," but often instructive.

A modification of the suture in tiers is a common procedure among German operators in performing abdominal incisions. This consists in dividing the various layers in the same parallel lines, but in different vertical planes. Thus the incision through the aponeurosis and muscle would not be made immediately under the skin incision, but a little to one side; while that in the peritoneum would not be done immediately beneath the division of the aponeurosis and muscle, but a little to one side under the skin incision. This method results in the formation of linear scars which are immediately superimposed by sound tissue in the layer above,—a considerable advance in the way of affording increased resistance to intra-abdominal pressure.

Later came the devices, as McBurney's and Stimson's, which, while retaining the method of apposition in layers, so perform the division in making the abdominal incision that the lines of incision, and therefore union, cross each other. Thus the common name of "gridiron incision" for McBurney's operation for appendicitis. In this incision, as is so well known, the skin and aponeurosis of the external oblique are divided in a line parallel to the latter's fibres over McBurney's point, and then the internal oblique and transversalis muscles are separated by blunt dissection in the direction of their fibres, which extend at almost right angles beneath the incision in the external oblique. In the last step the peritoneum is divided in the same line as the muscular separation. It is an almost ideal operation anatomically in that there is no transverse division of muscular or nerve fibres, and in the fact that muscular contraction closes the opening in the belly wall. The only weak spot is at the intersection of the lines of incision, and this is so small as to be negligible. For the prevention of hernia, this operation is wellnigh perfect: I can find but one case of hernia following it in looking over the literature upon the subject. While it requires more skill and time than the ordinary incision, or the method of overlapping to be described, it is used almost exclusively by the best operators in clean cases and by a great number in abscess cases as well.

Lewis A. Stimson's laparotomy incision for the prevention of hernia comes within the same class as the McBurney operation, since it is a method of suture by layers with the lines of incision crossing in different tiers of tissue, and pursuing in a general way the natural direction of their fibres. The incision is nearly hemispherical with its convexity downward, beginning about an inch above the symphysis; it is carried upward on either side towards the anterior superior spine, the length of the incision varying directly as the thickness of the wall, through the aponeurotic covering of the rectus, and, outside this muscle, through the aponeurosis of the external oblique. A flap of aponeurosis and integument is dissected from the rectus and turned up on the belly, and below the incision the aponeurosis is freed to a slight extent also. The recti are then separated, and the peritoneum is opened by a vertical incision in the middle line. In closing, the peritoneal line of sutures crosses the line of sutures in the tiers above, and we find in this procedure the analogue of the McBurney operation in its anatomical method and clinical results. No evidence of hernia has arisen in over fifty cases done by Stimson after his plan.

Brief mention might be made here of the silver-wire netting or filigree used so ingeniously by Phelps, Willy Meyer, and recently to good purpose by Bartlett (ANNALS OF SURGERY, July, 1903). Such a mode of support has of course no natural anatomical basis, and but limited surgical application, though of undoubted value in those exceptional cases in which it is unfortunately appropriate. It does not appear to be appropriate as a routine treatment of herniæ, since, acting as a foreign body, the silver wire tends to set up suppuration and sinus-formation, which weaken the wound and defeat the very object for which the wire netting is used. The indication for the netting is to reinforce the abdominal wall in cases where, owing to thinning out of stretched structures entering into hernial orifices, or to removal of diseased tissue, normal approximation of the abdominal wall cannot be secured. Somewhat similar comments in regard to their general application might be made of the McBurney and Stimson operations, though having a much wider sphere than the foregoing. Both are admirable in their place, but this is limited to the sites in which these operations are done, and both are restricted to the prevention of hernia.

I have emphasized the fact that the aponeuroses are the structures of essential importance in the operative prevention and cure of hernia of the abdominal wall, and therefore any method which has for its basis not only careful approximation of these parts, but the actual doubling of the strength of the wall by overlapping of the aponeuroses, must be anatomically most perfect. As examples of such procedures we have the operations of Lucas Championnière and Halstead for the cure of inguinal and that of Mayo for umbilical hernia. The first steps of the Championnière operation are the same as regards incision, treatment of the sac, etc., as in the Bassini operation; but in closing the wound, overlapping is secured by drawing the lower flap, consisting of the aponeurosis of the external oblique, up and under the upper flap by means of mattress sutures and bringing down the upper flap over the lower flap and stitching it to Poupart's ligament. The upper flap consists of the internal oblique, the aponeurosis of the external oblique, and, in the lowest angle of the wound, the conjoined tendon and the margin of the rectus. The cord is so displaced that it lies above the external oblique and under the skin. Championnière's record was recently reported to be 868 operations, with thirty-eight relapses (4.3 per cent.) and no deaths. This is better than the average results of the Bassini operation (about 5 per cent. of relapses).

Halstead practises a similar overlapping of the aponeurosis of the external oblique in his improved and perfected operation for inguinal hernia. After the internal oblique has been drawn down and stitched to Poupart's ligament, the external oblique is overlapped by inserting mattress sutures near the edge of the lower flap of the aponeurosis and carrying the sutures through the upper flap from behind and an inch or so from its free border, and by means of these sutures drawing the lower flap of aponeurosis up under the upper flap and tying them on its surface. The free margin of the upper flap is then brought down over the lower flap and stitched to Poupart's ligament. The cord is not transplanted, but lies beneath the cremaster muscle, which is overlapped by the internal oblique, while the latter is covered by the overlapped aponeurosis of the external oblique, a double doubling of the layers. Results speak louder than words. Halstead has had no recurrences following his operation for inguinal hernia in over ten consecutive years. (For description and excellent plates of this operation, see *Johns Hopkins Bulletin*, August, 1903.)

Mayo's operation for the cure of umbilical hernia consists in surrounding the hernial protrusion by two horizontally elliptical incisions carried down to the aponeurosis of the external oblique, baring this for an area of two and one-half to three inches in all directions about the neck of the sac; excising the sac and omentum; returning the bowel after separating adhesions; widening the ring by transverse cuts extending for an inch on either side of the ring; and, finally, overlapping of the aponeurotic margins of the ring from above downward for some two inches. The lower aponeurotic margin of the ring is drawn up under the upper aponeurotic margin by mattress sutures of silk after the peritoneum has been dissected from the upper lip and approximated to the peritoneal edge of the lower lip. Anatomically, this operation doubles the strength of the strongest structure of the abdominal wall; it avoids the necessity of tension, in approximating the borders of the ring, which has heretofore made the operation for umbilical hernia a byword and reproach in the way of mortality; and, finally, by this mode of closure, intra-abdominal pressure only tightens the hernial aperture by exerting force usually in a horizontal direction. This follows because the typical belly of umbilical hernia is long and pendulous in the vertical direction, and because intra-abdominal pressure acts along horizontal lines, as may be seen in the stretching of scars in the transverse and not in the vertical direction of the belly. Occasionally, however, in umbilical hernia, it is only feasible to overlap the aponeurosis from side to side in those exceptional cases where the long axis of the elliptical opening forming the hernial ring is vertical and not horizontal. In a recent personal operation such was the condition and mode of closure, it being impossible to overlap in the vertical direction.

Mayo's paper at the last annual meeting of the American Medical Association (*Journal of the American Medical Association,* July 25, 1903) fully described and illustrated the operation, and reported thirty-five cases of umbilical hernia operated on by overlapping of the aponeurotic margins of the ring, with only one partial relapse and no deaths. Over against this remarkable record we may put the results of operations by former methods in the hands of the best operators with 50 to 75 per cent. of relapses in the case of large umbilical herniæ, and with a mortality of 50 per cent in strangulated cases. Busse writes of twenty-two cases of operations for umbilical hernia performed during the five years prior to 1901. The mortality was 10 per cent. in all, 25 per cent. in the incarcerated cases, and suppuration in none. He gives the following summary of fifteen of these cases, whose after-history was traced. 1. That 75 per cent. of the large herniæ relapsed (from a double fist to a man's head in size). 2. That 50 per cent. of the medium-sized herniæ relapsed (from the size of a small apple to a goose-egg). 3. That among the cases having small herniæ there were no relapses (from the size of a hazel-nut to that of a walnut). Coley, in presenting and commenting upon this paper ("Progressive Medicine," June, 1903), remarks, "These figures demonstrate the great importance of early radical operation; it being evident that the chances of a permanent cure decreased with the size of the hernia. Busse states that it is only in small umbilical herniæ that a definite cure can be guaranteed. This is the opinion that Dr. Bull and myself have long held." However, Dr. Coley, in a recent letter to me, shows a more hopeful spirit in view of Mayo's wonderful success.

Another mode of overlapping has been independently practised by Blake, Piccolo, and Sapiejko. This is done in the neighborhood of the umbilicus by overlapping the opposing margins of the recti with their aponeurotic coverings for the cure of hernia in this region. The superfluous skin, umbilicus, and sac are removed by two vertical, elliptical incisions, after treating the hernial contents as seems proper. The aponeurosis over the recti is cleared of fat for the space of a few inches about the hernial orifice, and the peritoneum is dissected away from the borders of the recti and united by suture; or, if this is impossible, the muscles may be overlapped with their peritoneal coat intact. The hernial opening is slit upward and downward in the middle line as far as, but not through, the peritoneum, so as to make it vertically elliptical. Mattress sutures are then passed through the margins of the underlapping muscle and brought out at a suitable distance from the margin of the overlapping muscle, pulled tightly and tied. The edge of the overlapping muscle is tacked down to the aponeurosis of its fellow as in Mayo's operation. This procedure would not be safe or possible in many cases where one has not only to return a large mass of bowel into an abdominal cavity unused to contain it, but must at the same time lessen its capacity. It is as if a man wearing a skin-tight, single-breasted vest should eat an enormous meal, and then be compelled to wear it as a double-breasted garment. Then, unlike the operations of McBurney and Mayo, the action of the recti muscles tends to draw the muscles asunder in this method of approximation. In certain appropriate cases, where transverse laxity of the abdominal wall will permit of the operation, its success warrants its use.

When we see how wonderfully successful have been the special operations of Halstead, Mayo, and Championnière by the method of overlapping the aponeurosis for the *cure* of hernia, why should we not apply the same principle to the closure of *all abdominal incisions* for the *prevention* of hernia? For instance, I believe that the incision for appendectomy is more properly closed by this method than by any other. It is more easily and quickly done, is more appropriate in affording the greatest amount of room in diffuse abscess, and will be found to give as good results as the more difficult McBurney operation. Incisions for attacking the gall-bladder and ducts, the common middle-line incision, and incisions in any part of the belly wall can be closed to best advantage in consonance with anatomical reasoning and clinical results by this method. I desire to call particular attention to the fact that overlapping of the aponeurosis has the widest kind of applicability in abdominal surgery.

There is scarcely any abdominal incision which cannot be closed most successfully by this means to avoid hernia. Dr. C. H. Mayo, of Minnesota, writes me, "The overlapping method you mention for hernia and appendix operations we use constantly, and like it very much." In hernia with separation of the recti, and in epigastric and all ventral herniæ, it is *the* operation par excellence.

It has been the object of this paper to study the anatomy of the supporting structures of the abdomen and the various modes of approximating these structures in the closure of abdominal incisions in order to prevent or cure hernia of the belly wall. As a result of our study, we may formulate the following conclusions:

First. That the aponeurotic coverings are the chief supporting structures of the abdominal wall.

Second. That their approximation by overlapping, in doubling the strength of the aponeurotic layers, doubles the strength of the abdominal incision.

Third. That this being so, and the overlapping method being proved the best mode of curing abdominal hernia, it follows that, as prevention is better than cure, it is wiser to *prevent* hernia by employing this principle in closing all abdominal incisions than to be forced to use it later to cure postoperative hernia.

The following is a description of the technique employed for the prevention of abdominal herniæ by overlapping the aponeurosis. This applies to the closure of incisions made in the middle line or for attacking appendix, gall-bladder, etc.

FIG. 5.

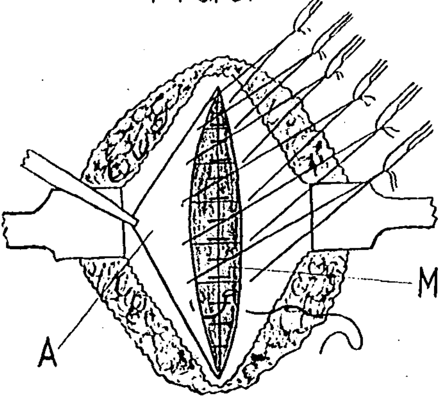

FIG. 6.

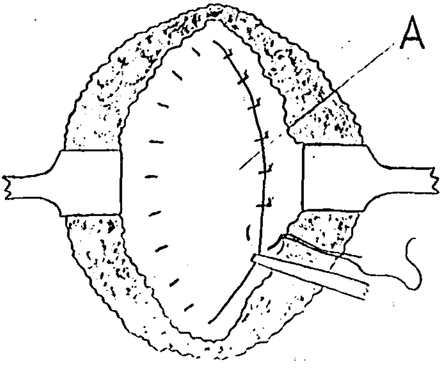

FIG. 5.—Showing type of operation for closing an abdominal incision by overlapping of aponeurosis. First step: muscle coapted by interrupted sutures. (A) Flap of aponeurosis lifted from muscle (M); interrupted stitches have been introduced through opposing (right) margin of the aponeurosis and, having been carried over the surface of the muscle, are brought through a portion of the base of the raised flap (A). (This is depicted by needle in illustration, and the ends of the sutures are held by hæmostatic forceps ready for tying.)

FIG. 6.—Same, showing second step. The first row of sutures shown in Fig. 5 has been tied, thus approximating the right cut-margin of the aponeurosis to the base of the aponeurotic flap (A). Then flap (A) is brought over the surface of the aponeurosis and its cut-margin attached to this structure by interrupted sutures forming the overlap (portrayed by needle in position). Fig. 4 illustrates same in cross-section.

The integument and subcutaneous tissue are incised down to the aponeurosis. The aponeurosis is bared by reflecting back the skin and fat for a space of an inch and a half on each side of the incision. The aponeurosis is next incised in the same line and directly beneath the skin incision, and two flaps, one on each side of the incision, are raised from the underlying muscle by blunt dissection. One flap of aponeurosis is freed for an inch or so from its cut margin; the other for about half that distance. The incision through the rest of the abdominal wall is completed as usual. In closing, the peritoneum is approximated by a continuous suture. It may be wise in weak, fatty walls to now introduce two or three retention sutures placed well back from the margins of the wound and penetrating all layers above the peritoneum. The muscle, if well developed, is coapted by interrupted sutures. Then the cut edge of the aponeurotic flap, which was but slightly freed, is stitched to the base of the opposing flap (Figs. 5 and 6) by interrupted or mattress sutures. The free margin of the opposing flap is lapped over the other one and stitched down to the surface of the aponeurosis by interrupted or continuous suture. A drain of gauze wrapped about with rubber tissue, or a roll of rubber tissue alone, leading from the lower angle of the wound, should be inserted between the fat and aponeurotic layer in cases where there has been much manipulation or where the adipose tissue is thick. The skin may be coapted with the Michel clamp, buried silver wire, or other suture. The retention sutures are of silkworm gut; medium catgut is used for the lower layers, plain in the case of the peritoneum, chromicized for the muscle and aponeurosis. The retention sutures, if used, are employed merely to support the wall until the dangers of vomiting and meteorism are passed and union has begun.